

# PATENT SPECIFICATION

NO DRAWINGS

1.183,264



1.183,264

Date of Application and filing Complete Specification: 24 Jan., 1967.

No. 3610/67.

Application made in France (No. 47033) on 25 Jan., 1966.

Complete Specification Published: 4 March, 1970.

Index at acceptance:—B2 K(1A2, 2Y, 2B, 3D, 4X, 5A, 6A, 7AY, 7A3, 8D, 9J, 9M, 9QY, 9Q2, 9Q5, 9Q8, 9Q9, 9Q10, 9Q12); C3 B(1A, 1C1, 1C6AX, 1C6X, 1C8B, 1C8P, 1C8R, 1C8T, 1C9B, 1C12, 1C13X, 1C22, 1C24, 1C25, 1C33B, 1D2C, 1L2B, 1L3A, 1L4D, 1L6G); C3 R(1A, 1C1, 1C6AX, 1C6X, 1C8B, 1C8P, 1C8R, 1C8T, 1C9B, 1C12, 1C13X, 1C22, 1C24, 1C25, 1C33B, 1L2B, 1L3A, 1L4D, 1L6G, 3A, 3C1, 3C6AX, 3C6X, 3C8B, 3C8P, 3C8R, 3C8T, 3C9B, 3C12, 3C13X, 3C22, 3C24, 3C25, 3C33B, 3L2B, 3L3A, 3L4D, 3L6G, 27K2A, 27K2C1, 27K2C6AX, 27K2C6X, 27K2C8B, 27K2C8P, 27K2C8R, 27K2C8T, 27K2C9B, 27K2C12, 27K2C13X, 27K2C22, 27K2C24, 27K2C25, 27K2C33B, 27K2L2B, 27K2L3A, 27K2L4D, 27K2L6G, 29A, 29C1, 29C6AX, 29C6X, 29C8B, 29C8P, 29C8R, 29C8T, 29C9B, 29C12, 29C13X, 29C22, 29C24, 29C25, 29C33B, 29L2B, 29L3A, 29L4D, 29L6G)

International Classification:—B 44 d 5/08

## COMPLETE SPECIFICATION

### New Anti-Friction Compositions and Process of Application

We, SOCIETE INDUSTRIELLE DES COUSSINETS, a Company organised and existing under the laws of France, of 12, rue du General Foy, Paris 8e, France, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a process for the production of bearings, or friction surfaces, in particular bearings consisting of a thermosetting or thermohardening combination of particular resins acting as binders for solid inorganic anti-friction fillers.

It is already known that inorganic, organic, metalloidal or metallic fillers may be incorporated in synthetic resins such as phenol formaldehyde fluorocarbons, epoxy, silicones, polyamides, polyoxymethylenes, polyurethanes, polycarbonates and alkyds, for producing composite materials which comply with the operational requirements of bearings for spindles in rolling motion. These charges or fillers normally consist of such materials as polytetrafluoroethylene, iron, lead, tin, copper, bronze, mica, asbestos, oxides of lead or iron. The known compositions, each with its particular merit, nevertheless have well known shortcomings, or even serious disadvantages in some conditions of use. The thermoplastic resins for example, exhibit rapid increase of their coefficient of friction as the temperature rises. The thermosetting

resins employed normally lack the required pliability and adhesion, and the cross linking catalysts employed render them sensitive to temperature and liable to creep. On the other hand, many active fillers are frequently unstable, fusible or relatively incompatible with the binders. Lead powder or lead oxides thus play the part of polymerisation catalysts for phenolic resins modified by drying oils, or of silicone resins.

The known anti-friction compositions are either rigid and massive from which the friction elements or units can only be produced by machining, resulting in high cost price, or their use is limited since they deteriorate as soon as the operating temperature exceeds a value normally below 130°C, or they are affected by environmental factors and offer little resistance to acids, bases, cold water or boiling water, oils and solvents, or they are difficult to apply on metal bases due to lack of adequate adhesivity, which necessitates having to use mechanical anchoring.

A main object of the present invention is to minimise or eliminate these shortcomings.

According to the present invention a process for the production of a bearing comprises mixing, in a solvent at least one unmodified oil soluble thermosetting phenolic resin, or etherified melamine formaldehyde resin or alcohol modified resole plus at least one drying oil modified resole or or a polyester plasticised resole soluble in oils and aromatic

[Price 5s. 0d.]

hydrocarbons epoxy resin or combinations thereof with a siloxane epoxy resin plus a filler, partially evaporating the solvent until the mixture attains a putty like consistency, applying the mixture to a preheated metal base to form a liner thereon, and heating the resulting laminate at a temperature between 180°C and 300°C.

The bearings so produced possess a degree of thermoplasticity, the rigidity required, and a low coefficient of friction, and they operate successfully at temperatures of up to 250°C, without degradation or decomposition.

The putty-like mixture is usually applied in the form of coatings of thin layers in preferably continuous form, on the metal base or backing.

Preferably the metal base is coated with a primary coat of polyvinyl butyral, and thus coated is preheated to a temperature of between 80°C and 120°C prior to the laminating process.

After the putty-like mixture is applied to the metal base it is advantageous that it be subjected to a preliminary rolling operation following by heating to between 40° and 70°C and is thereafter subjected to further rolling until the laminate reaches a desired thickness, prior to being heated at between 180° and 300°C.

One resin ingredient of the putty-like mixture may be:

(a) The unmodified oil soluble thermosetting phenol-formaldehyde resins originating from a phenol substituted preferably at the para position, which are soluble in aromatic oils, are thermosetting and will hereinafter be referred to as resins No. 1.

Examples of phenols which may be employed are p-cyclohexylphenol, p-p'-hydroxydiphenol - dimethylmethane, p - tert - butylphenol and p - tert - amylphenol.

These resins endow the compositions with hardness and are compatible with epoxy resins.

(b) Resols plasticised by polymeric-esters, which establish solubility in oils, compatibility with epoxy resins of high molecular weight and melamine resins, and solubility in aromatic hydrocarbons. These esters result from a condensation reaction between saturated or unsaturated polyacids containing a relatively great number of atoms of carbon, and polyalcohols such as ethylene-glycol or propylene-glycol; they establish the required plasticity. An example is the adipate of diethylene-glycol.

These plasticised resols will be referred to as resins No. 5. These resins offer great mechanical strength as well as great resistance to chemical agents.

(c) The alcohol modified resols consisting of the products of the reaction of phenol and formaldehyde in an alkaline environment, these products being modified by a reaction

with alcohols and preferably with p.tert-butanol or benzyl alcohol. The resols are soluble in lower aliphatic alcohols, but insoluble in aromatic oils and hydrocarbons. After modification, they become insoluble in alcohols, but soluble in ketones, aromatic oils and hydrocarbons. These resols will be referred to as resins No. 2. These resins endow the putties with fluidity and promote adhesion. They are compatible with epoxy resins.

(d) The etherified melamine formaldehyde resin is preferably hexamethoxymethylmelamine, which will be referred to as resin No. 10 and after heat treatment imparts to the compositions exceptional resistance against acids, bases, detergents and solvents. It equally establishes great hardness whilst maintaining a degree of flexibility or resiliency. Its miscibility is total with the resins bearing the references 1 to 9 in the present text.

The resins above referred to may be employed alone or mixed with each other, in any proportions. Their relative proportions depend on the resiliency and hardness to be imparted to the bearing laminate.

The other resin ingredient of the putty like mixture may be:

(e) Drying oil modified resols are preferably modified by vegetable drying oils possessing double conjugated bonds and a ketonic group. The resols modified by castor oils will be referred to as resins No. 3. The resols modified by tung oil will be referred to as resins No. 4. These resins are capable of undergoing substantial deformations.

(f) The siloxanes which cannot be cross linked by themselves but are copolymerisable with resins containing free hydroxyl groups, such as phenolic and epoxy resins. A preferred compound is dimethyltriphenyltrimethoxy siloxane, which will for convenience be referred to herein as resin No. 7. These resins offer high resistance to temperature. The epoxy resins resulting from condensation in an alkaline environment of epichlorohydrin and diphenylolpropane, having a molecular weight between 470 and 3,800, and preferably between 2,000 and 3,000, which resins will be referred to as resins No. 8. These resins have exceptional chemical resistance, excellent mechanical qualities, and satisfactory dimensional stability.

The resins (f) and (g) may be cross linked at the time of use by means of any appropriate hardeners.

These different resins (e), (f), (g) are employed mixed with the resins (a), (c), (b), (d) to obtain the desirable qualities of hardness and resiliency at the same time. To obtain products having very high performance however, the ratios between the resins should vary within relatively narrow limits. The following compositions are preferred:

the resins (a) and (c) with the resins (g)

- in the proportions of 40 to 48g of resins (a) and 35 to 40g of resins (c), to 100g of resins (g);
- 5 the resins (a) with the resins (e), in the proportion of 40 to 50g of resins (e) to 100g of resins (a);
- the resins (e) with the resins (b) in the proportion of 75 to 85g of resins (e) to 100g of resins (c);
- 10 the resins (a) with the resins (g) in the proportion of 40 to 48g of resins (a) to 100g of resins (g);
- the resins (f) and the resins (g) with the resins (c) in the proportions of 45 to 55g of resins (f) and 220 to 280g of resins (g), to 100g of resins (b);
- 15 the resins (a) and the resins (c) with the resins (f) and the resins (g), in the proportions of 20 to 28g of resins (a) and 18g to 22g of resins (c) to 20g of resins (f) and 100g of resins (g);
- 20 the resins (d) with the resins (f) and the resins (g), in the proportions of 5 to 12g of resins (d) to 6 to 9g of resins (f) and 100g of resins (g).
- 25

One or more unmodified silicone resins, referred to as resins No. 6, may be added to these different resins, to obtain a specific result, such as an improvement in thermal stability or imperviousness to boiling water.

- 30 The different resins referred to, are employed in the forms and conditions specified hereinafter:

- 35 the resins No. 1, in the form of a liquid, in approximately 50% by weight solution, in a mixture of equal weights of butanol and xylol;
- the resins No. 2, in the form of a liquid, in a 67%—70% by weight solution in a mixture of equal weights of butanol and xylol;
- 40 the resins No. 3, in the form of a viscous liquid, in approximately 75% by weight solution, in a mixture of equal weights of butanol and xylol;
- 45 the resins No. 4, in the form of a liquid, in approximately 70% by weight solution, in a mixture of equal weights of butanol and xylol;
- 50 the resins No. 5, in the form of a liquid, in approximately 60% by weight solution, in a mixture of equal weights of butanol and xylol;
- 55 the resins No. 6, in the form of a liquid, in approximately 50% by weight solution, in toluol;
- the resins No. 7, in the form of a liquid, without solvent;
- 60 the resins No. 8, in the form of a liquid, in approximately 50% by weight solution, in cyclohexanone;
- the resins No. 9, in the form of a liquid, in approximately 20% by weight solution, in cyclohexanone;

the resins No. 10, in the form of a wax or of a liquid, without solvent. 65

It is advantageous to incorporate a plasticiser in the mixtures of the resins previously described. As preferred plasticizers are ethylene-glycol polymers, preferably having a molecular weight of between 200 and 6,000. These plasticisers also act as a wetting agent for application of the new compositions on a subjacent metal layer. To this end, Carbowax 400 (Carbowax is a Registered Trade Mark) produced by the Union Carbide Chemical Company may be employed. 70 75

Anti friction fillers are added to the mixtures of binders and plasticisers described heretofore, in quantities varying according to their characteristics and compatibility. The following products are however preferred: 80

neutral anhydrous aluminium phosphate, which may be employed in the proportion of up to 20% of the weight of the mixture of hard resins and resilient resins; 85

lead sulphide, in the proportion of up to 15% of the weight of the same mixture. Natural lead sulphide may be employed if it is sufficiently pure and free of silica, but it is preferable nevertheless to employ synthetic galena of 11.4% by weight of sulphur resulting from the reaction of lead with an excess of sulphur at a temperature of 1150°C to 1200°C; 90 95

natural or synthetic graphite in powder form, in the proportion of up to 5% by weight of the mixture of hard resins and resilient resins; Alkaline borophosphates corresponding to the following general formula: 100



in which:

$n$  may vary from 1.5 to 2.5  
 $m$  " " " 1.5 to 2.5  
 $p$  " " " 0.5 to 2  
 $M$  represents an alkaline metal. 105

These borophosphates may be associated moreover with at least one of the following oxides:  $Al_2O_3$ ,  $PbO$ ,  $MgO$ ,  $FeO$ ,  $Fe_2O_3$ ,  $BeO$ . They have been described in the French Patent Specification No. 1,380,678. Favourable results have been obtained with the borophosphates containing a maximum of  $Mg$  and  $Al$  ions, such as the following, which will be referred to as  $P$  and in which the proportions are given by weight: 110 115

$P_2O_5$	46.71%	
$B_2O_3$	21.13%	
$Na_2O$	18.82%	120
$MgO$	8.15%	
$Al_2O_3$	5.17%	

All the products previously specified may



be employed mixed with each other and in any proportions.

A number of additives may be incorporated in the fundamental combinations between the resins and fillers, to facilitate production of the anti-friction compositions or their application on the metal backings or to improve their final characteristics. Such additives may consist of:

10 polyvinyl formal or butyral in 20% solution by weight in cyclohexane, employed in the proportion of 0 to 15% by weight of the mixture between hard resins and resilient resins. The polyvinyl butyral preferably contains between 9 and 13% by weight of polyvinyl alcohol, which will be referred to as resin No. 9.

15 a lubricating agent for reducing friction on placing the friction element in motion, consisting of 1 to 5% of the weight of the mixture of a semi-metallic element of Group V of the periodic table, and preferably bismuth.

20 Among the numerous possible mixtures of resin binders, the following are given by way of example, in which the ratios given for the resins refer to the weights of the resins in the condition specified in the foregoing, that is to say in solution in solvents or as they are:

30 Mixtures of resins No. 4 and resins No. 8 in the ratio 1/0.8;

mixtures of resins No. 8 and resins No. 5 in the ratio 1/0.4;

35 mixtures of resins No. 8 and resins No. 2 in the ratio 1/0.72;

mixtures of resins No. 8, resins No. 1 and resins No. 2 in the ratios 1/0.42/0.4;

mixtures of resins No. 8, resins No. 2 and resins No. 5 in the ratios 1/0.36/0.4;

40 mixtures of resins No. 8, resins No. 1, resins No. 2 and resins No. 9 in the ratios 1/0.42/0.40/0.05;

mixtures of resins No. 1 and resins No. 4 in the ratio 1/0.575;

45 mixtures of resins No. 1 and resins No. 3 in the ratio 1/0.45;

mixtures of resins No. 8, resins No. 5 and resins No. 3 in the ratios 1/0.4/0.32;

50 mixtures of resins No. 8, resins No. 1 and resins No. 3 in the ratios 1/0.5/0.32;

mixtures of resins No. 8, resins No. 1, resins No. 2 and resins No. 7 in the ratios 1/0.24/0.40/0.20;

55 mixtures of resins No. 8, resins No. 7, resins No. 10 and resins No. 9 in the ratios 1/0.07/0.125/0.05.

Mixtures of binders and anti-friction substances include:

60 the mixture A formed by a mixture of resins No. 1 and No. 3 and complex diborophosphate P, in the proportion of 20 to 45g of diborophosphate P to 100g of the mixture of resins in their condition as specified in the foregoing;

65 the mixture B formed by the resins No. 4

and No. 6 mixed with complex diborophosphate P, in the proportion of 20 to 45g of diborophosphate P to 100g of the mixture of resins in their condition as specified hereinbefore;

the mixture C formed by the resins No. 1, No. 2 and No. 8 mixed with synthetic galenite in the proportion of 4 to 16g of synthetic galenite, and with aluminium phosphate  $AlPO_4$  in the proportion of 10 to 25g of phosphate, to 100g of the mixture of resins in their condition as specified hereinbefore;

the mixture D formed by the resins No. 1, No. 2, No. 8 and No. 9, mixed with synthetic galenite in the proportion of 3.8 to 15.5g of galenite, and with aluminium phosphate  $AlPO_4$  in the proportion of 9 to 24g of phosphate, to 100 g of the mixture of resins in their condition as specified hereinbefore;

the mixture E formed by the resins No. 1, No. 2, No. 8 and No. 7, mixed with synthetic galenite in the proportion of 4 to 16g of galenite, and with aluminium phosphate  $AlPO_4$  in the proportion of 10 to 27g of phosphate, to 100 g of the mixture of resins in their condition as specified hereinbefore;

the mixture F formed by the resins No. 2 and No. 8, mixed with synthetic galenite or galena in the proportion of 4 to 17g of galenite, and with aluminium phosphate  $AlPO_4$  in the proportion of 11 to 28g of phosphate, to 100 g of the mixture of resins in their condition as specified hereinbefore;

the mixture G formed by the resins No. 8, No. 7, No. 9 and No. 10, mixed with synthetic galenite in the proportion of 4 to 15g of galenite, and with aluminium phosphate  $AlPO_4$  in the proportion of 10 to 25g of phosphate, to 100g of the mixture of resins in their condition as specified hereinbefore.

Among the bearing compositions used according to the invention, to which a lubricant has been added, the following may be specified by way of example:

the composition formed by the mixture A with the addition of bismuth in the proportion of 0.4 to 3% of the weight of A;

the composition formed by the mixture C with the addition of aluminium phosphate  $AlPO_4$  in the proportion of 9 to 24% by weight, and of graphite in the proportion of 0.4 to 3% by weight, in relation to C;

the composition formed by the mixture D with the addition of graphite in the proportion of 0.4 to 3% of the weight of D;

the composition formed by the mixture E with the addition of aluminium phosphate  $AlPO_4$  in the proportion of 9 to 24% by weight, and of graphite in the proportion of 0.4 to 3% by weight in relation to E;

70

75

80

85

90

95

100

105

110

115

120

125

130

- the composition formed by the mixture F with the addition of graphite in the proportion of 0.4 to 3% of the weight of F; the composition formed by the mixture G with the addition of graphite in the proportion of 0.4 to 3% of the weight of G.
- Depending on the operating conditions, the anti-friction composition and on the technology for applying the compositions, the proportions of its component elements may be varied within the limits specified in the foregoing.
- The compositions may be produced in different ways. A "master" mixture of resins, a plasticiser and preferably a resin No. 9, may thus be produced in a first stage; to this end, the resins in their solvents are mixed in the desired proportions. The solvents are then partially eliminated until the mixture attain the consistency of putty. The anti-friction substances are then added, and the paste is worked initially in a grinder or the like. The paste is finally brought to a putty-like consistency in a heated multi-cylinder rolling mill or the like.
- The anti-friction compositions of the invention then appear in the form of a putty still containing a few per cent of volatile solvents, which is applied on the metal base or backing selected, and then made to undergo thermosetting.
- A preferred method of applying these compositions comprises depositing continuously in the form of an extruded section along the longitudinal axis of the appropriate metal base or backing, the said section, preferably being cylindrical, which may be produced by any known means such as extrusion, drawing or rolling. The cross-sectional area of the section is appropriate for the width of the base and for the final thickness required for the bearing laminate.
- After undergoing the conventional cleaning, rinsing and drying operations, the metal base or bearer receives a primary or initial coating preferably formed by a polyvinyl butyral which offers the advantage of enhancing impact strength. The evaporation of the volatile solvents contained in the primary coating is then carried out by appropriate heating of the base or bearer. The anti-friction section is then deposited on the base or bearer preheated to 80°C to 120°C, on which it undergoes a preliminary rolling operation followed by heating between 40°C and 70°C to allow the putty to spread on the base or bearer whilst intimately assuming its contours, and to facilitate the operations of rolling to size, consecutive rolling operations being performed until the desired thickness is reached. A film of surface lubricant, is finally deposited on the surface of the coating, and the final proportion of solvent is evaporated progressively to produce gelling, then hardening and final cross linking between 180°C and 300°C by exposure of the coating to the thermic radiation of appropriate sources of heat such as infra-red lamps for example. The metal base or bearer thus coated with the anti-friction composition is ready to undergo operations of forming to shape by known techniques. Good results have been obtained with graphite and tungsten sulphide as surface lubricating agents.
- The bearings of the invention show high resistance against chemical agents, compactness and absence of porosity, satisfactory thermal stability up to approximately 200°C, combination of generally contradictory qualities, i.e. hardness on the one hand and a degree of resilience on the other hand, good resistance to abrasion and low coefficient of friction. Because of the particular physical consistency of the anti friction compositions i.e. its putty like nature continuous application processes on endless belts can be carried out. Moreover the combinations can be employed in thin and tightly adhering layers; the metal bearers thus coated lend themselves easily to the operations for forming to shape; also the laminate bearing in the form of thin layers has the advantage of facilitating dissipation of heat during operation and of preventing local overheating.
- The invention will now be further described with reference to the following Examples:
- EXAMPLE 1
- A composition was produced by mixing
- |   |     |
|---|-----|
| resin No. 1   | 100 |
| resin No. 2   |     |
| resin No. 8   |     |
| Polyethylene-glycol having the molecular weight 400                     |     |
| graphite powder   | 105 |
| lead sulphide powder  |     |
| neutral and anhydrous aluminium phosphate, and complex borophosphate P. |     |
- The following were introduced consecutively into a vessel of stainless steel equipped with an agitator of the same material:
- |  |     |
|--|-----|
| 110g of solution of resin No. 1, 50% by weight in a mixture of equal weights of butanol and xylol, |     |
| 105g of solution of resin No. 2, 70% by weight in a mixture of equal weights of butanol and xylol, | 115 |
| 275g of solution of resin No. 8, 50% by weight in cyclohexanone,                                   |     |
| 10g of polyethylene-glycol having the molecular weight 400.  | 120 |
- After mixing these intimately, approximately 125g of solvent was eliminated by heating to 120°C and under constant agitation. After rapid cooling, the following were introduced:

5g of graphite  
50g of lead sulphide  
50g of anhydrous aluminium phosphate  
50g of complex borophosphate P.

- 5 The whole was ground until a coarse rudimentary mixture had been formed. The product issuing from the grinder was subjected to physical plastification by passage through a multicylinder rolling mill or crusher.
- 10 The putty or paste issuing from this crusher or kneader was introduced into an extrusion press of the screw or worm type brought to the temperature of 50°C, from which cylinders were drawn of a length of 15 500 mms and of a diameter of 4 mms. The cylinder thus obtained was placed on the surface and along the longitudinal axis of a mild steel bearer of a length of 500 mms, a width of 30 mms and a thickness of 1.375 20 mms., which had been preheated to 100°C.
- The cylinder of paste was rolled on the steel bearer in such manner as to impart to it the pattern of the final shape, that is to say a rectangular section without lateral overflow 25 of paste. The paste thus applied was heated by infrared radiation until its temperature reached 60°C. Two rolling operations were performed to produce a total thickness (steel+paste) of 1.7 mms. The paste flowing 30 over the edge of the bearer was trimmed off. A film of graphite was applied with a fabric pad.

- 35 Drying was performed progressively and continuously by infrared radiation until the product had gelled, the product being polymerised finally by heating for 20 minutes at the mean temperature of 270°C.

- 40 The total final thickness was 1.675 mms, that is to say that the thickness of the laminated coating was 3/10ths of a mm.

- 45 The strip thus coated was formed into the shape of an U, the anti-friction lining being on the inner side. This U was subjected to a load of 3 deca Newton per cm<sup>2</sup> of projected surface, and bore on a steel spindle of a diameter of 45 mm revolving at 3,100 r.p.m. Dry friction prevailed. The speed specified was reached 25 seconds after starting. After 10 hours in operation, the anti-friction lining had not incurred any pronounced wear, the temperature having remained constant at 135°C.

#### EXAMPLE 2

A composition was produced by mixing

- 55 resin No. 1  
resin No. 2  
resin No. 8  
resin No. 9  
polyethylene-glycol of molecular weight 400  
60 graphite powder  
lead sulphide powder  
neutral and anhydrous aluminium phosphate.

25g of 20% solution of resin No. 9 in cyclohexanone was added to the weights of the resins 1, 2 and 8 specified in Example 1. The anti-friction materials were introduced in the same quantities as in Example 1. The sequence of operations was identical.

The following test was performed on the coated final strip: the strip was shaped in a press into a cylindrical ring having an internal diameter of 30 mms and a length of 10 mms, the inner side consisting of the anti-friction lining. The ring was subjected to an abrasion test; to this end, it was stationarily positioned on a steel shaft turning at 60 r.p.m. A loading of 1,000 deca Newtons per cm<sup>2</sup> was applied on the ring, resulting in a unitary pressure of 166 bars, approximately. No heating exceeding 45°C was observed. No appreciable wear was detected after 1,500 hours.

#### EXAMPLE 3

A composition was produced by mixing

- resin No. 1  
resin No. 2  
resin No. 8  
resin No. 9  
polyethylene-glycol of molecular weight 400  
graphite powder  
lead sulphide powder and complex di-borophosphate P.

The same quantities of resins and of fillers were employed as in Example 2 and in the same manner, but with elimination of approximately 145g of solvent, instead of 125g.

The coated metal strip was tested as in Example 1. No appreciable wear was observed after a period of 9½ hours. The temperature of the shaft of the machine was close to 135°C. The specified speed was reached in 30 seconds.

#### EXAMPLE 4

A composition was produced by mixing

- resin No. 1  
resin No. 2  
resin No. 7  
resin No. 8  
polyethylene-glycol of molecular weight 400  
graphite powder  
lead sulphide, and neutral and anhydrous aluminium phosphate.

The same procedure was applied as in the preceding Examples, with the following quantities:

- |                     |   |     |
|---------------------|---|-----|
| 60g of resin No. 1  | } in their form as specified hereinbefore | 120 |
| 100g of resin No. 2 |   |     |
| 250g of resin No. 8 |   |     |

- 10g of polyethylene-glycol of molecular weight 400  
50g of resin No. 7 in the liquid state, without solvent.
- 5 After mixing these intimately, approximately 125g of solvent was eliminated by heating to 120°C and under constant agitation.
- 10 After cooling, the following charges or fillers were added:
- 6.5g of graphite  
25 g of lead sulphide powder  
100 g of neutral and anhydrous aluminium phosphate.
- 15 The sequence of operations was identical to that of the preceding Examples. The following test was performed: the coated strip, of a length of 500 mms long, was immersed halfway into a bath with a constant level of boiling water (tap water). After 400 hours, the scale deposited on the immersed part was eliminated, and the thickness was measured. The average of 6 values was 1.677 mms for an original thickness of 1.675 mms.
- 20 This led to the deduction that the anti-friction product had incurred practically no swelling in boiling water.
- EXAMPLE 5
- A composition was produced by mixing
- 30 resin No. 2  
resin No. 8  
polyethylene-glycol of molecular weight 400  
graphite powder
- 35 lead sulphide powder and neutral and anhydrous aluminium phosphate.
- The operation was conducted as in Example 1, employing:
- 40 180g of resin No. 2 } in their state as  
250g of resin No. 8 } specified  
hereinbefore
- 5g of polyethylene-glycol of molecular weight 400.
- 45 115g of solvent was eliminated, and the following were added after cooling:
- 5g of graphite  
75g of lead sulphide  
75g of neutral and anhydrous aluminium phosphate.
- 50 The sequence of operations was identical to that of the preceding Examples.  
Rings were made from the strip thus coated, which under a cyclic loading of 178 decanewtons per cm<sup>2</sup> of projected surface, with-
- stood 1,300,000 cycles without abnormal wear. 55
- EXAMPLE 6
- A composition was produced by mixing
- resin No. 10  
resin No. 7  
resin No. 8  
polyethylene-glycol of molecular weight 400  
resin No. 9  
graphite powder  
lead sulphide powder, and  
neutral and anhydrous aluminium phosphate. 60
- The production technique was that of the preceding examples, employing: 70
- 50g of resin No. 10 } in their state as  
30g of resin No. 7 } specified  
400g of resin No. 8 } hereinbefore
- 10g of polyethylene-glycol of molecular weight 400  
25g of resin No. 9 75
- After mixing intimately by stirring, approximately 135g of solvent was eliminated by heating to 120°C and under constant agitation. The following were added after cooling: 80
- 5g of graphite powder  
20g of lead sulphide powder  
75g of neutral and anhydrous aluminium phosphate. 85
- The sequence of operations was identical to that of the preceding Examples.  
The same fatigue test as that of Example 5 was applied to the strip thus coated. No abnormal wear of the rings was observed after 1,400,000 cycles. 90
- EXAMPLE 7
- A composition was produced by mixing
- resin No. 10  
resin No. 7  
resin No. 8  
resin No. 9  
polyethylene-glycol of molecular weight 400  
graphite powder  
molybdenum sulphide powder  
lead sulphide powder,  
and neutral and anhydrous aluminium phosphate. 95
- The production technique remained that of the preceding Examples. The following were employed: 105



50g of resin No. 10 }  
 30g of resin No. 7 } in their state as  
 400g of resin No. 8 } specified  
 25g of resin No. 9 } hereinbefore

5 10g of polyethylene-glycol of molecular weight 400.

After mixing intimately by stirring, 135g of solvent was eliminated by heating to 120°C and under constant agitation.

10 The following were introduced after cooling:

15 5g of graphite powder  
 10g of molybdenum sulphide powder  
 40g of lead sulphide powder  
 75g of neutral and anhydrous aluminium phosphate.

35 10 parts by weight of resin No. 10  
 6 " " " " " No. 7  
 40 " " " " " No. 8  
 40 " " " " " cyclohexanone  
 2 " " " " " polyethyleneglycol (molecular weight 400)  
 5 " " " " " resin No. 9  
 40 1 part " " " " " graphite powder  
 10 parts " " " " " lead sulphide powder  
 15 " " " " " neutral and anhydrous aluminium phosphate  
 129 parts

45 The resins named were used in the state as previously described herein, by the methods of Example 6. During the operations leading to the putty 29 parts of the solvents were evaporated.

50 A strip of mild steel, was covered with the putty as in Example 1. With the covered strip a ring was formed having the following specification:

55 —thickness of the back of steel 1.32 mm  
 —nominal coating thickness 0.254 mm  
 of the invention 15.113 mm  
 —drilling 25.4 mm  
 —length

60 This ring was placed in a housing to which a static charge of 43,500 kg was applied. The whole was mounted on a shaft of mild steel with a diametral play of 0.635 mm. This shaft, lubricated with 10 w lubricating oil, rotated at 750 r.p.m.

65 The life of the ball-bearing reached 1,200 hours for a PV of 40 000 (P=charge in kg per sq. centimetre of projected surface, V=  $\pi$  multiplied by the diameter multiplied by the number of revolutions per minute).

#### WHAT WE CLAIM IS:—

70 1. A process for the production of a bearing comprising mixing in a solvent, at least

The sequence of operations remained identical to that of the preceding Examples.

20 An adhesion test was performed on a test specimen cut from the coated strip, of a length of 125 mm and a width of 25mms. One of the extremities of the test specimen was clamped horizontally over a length of 20 mms on the stationary part of a torsion test machine, the other being clamped over 25 a length of 20 mms on the displaceable part of the same. A twist of 180° was applied, followed by 7 alternating twists of 360°. There were no traces of detachment of the coating of the specimen, after this test. 30

#### EXAMPLE 8

A compound is prepared comprising the following:

one unmodified oil soluble thermosetting phenolic resin, or etherified melamine formaldehyde resin or alcohol modified resole or a polyester plasticised resole soluble in oils and aromatic hydrocarbons plus at least one drying oil modified resole or epoxy resin or combinations thereof with a siloxane plus an anti-friction filler, partially evaporating the solvent until the mixture attains a putty like consistency, applying the mixture to a preheated metal base to form a liner thereon, and heating the resulting laminate at a temperature between 180°C and 300°C.

2. A process according to Claim 1, wherein the metal base is coated with a primary coat of polyvinyl butyrd 1, and thus coated is preheated to a temperature of between 80°C and 120°C prior to the laminating process.

3. A process according to Claim 1 or Claim 2, wherein after the putty-like mixture is applied to the metal base it is subjected to a preliminary rolling operation followed by heating to between 40° and 70°C, and is thereafter subjected to further rolling until the laminate reaches a desired thickness, prior to being heated at between 180° and 300°C.

4. A process according to any of Claims 1 to 3, wherein the etherified melamine formaldehyde resin is hexamethoxymethyl melamine.

5. A process according to any of Claims 1



to 4, wherein the unmodified oil soluble thermosetting phenolic resin is a phenol formaldehyde resin derived from para-substituted phenols.

5 6. A process according to any of Claims 1 to 5, wherein the epoxy resin is obtained by the condensation of epichlorohydrin and diphenylolpropane in an alkaline environment and has a molecular weight between 470 and 10 3800.

7. A process according to any of Claims 1 to 6, wherein the siloxane is dimethyltri-phenyltrimethoxysiloxane.

15 8. A process according to any of Claims 1 to 7, wherein there is included in the mixture a plasticizer chosen from the polymers of ethylene-glycol of a molecular weight of between 200 and 6000.

20 9. A process according to any of Claims 1 to 8, wherein the filler is chosen from neutral anhydrous aluminium phosphate, lead sulphide, natural or synthetic graphite, and the alkaline borophosphates.

25 10. A process according to Claim 9, wherein the alkaline borophosphates correspond to

the general formula  $P_2O_5 \cdot nB_2O_3 \cdot mM_2O$ ,  $pH_2O$  where  $n$  and  $m$  each is within the range between 1.5 and 2.5,  $p$  is from 0.5 to 2.0 and  $M$  is an alkali metal.

11. A process according to any of Claims 1 to 10 wherein there is incorporated in the mixture a lubricating agent chosen from semi-metallic elements of Group V of the Periodic Table according to Mendeleef.

12. A process according to Claim 11, wherein the lubricating agent is bismuth. 35

13. A process for the production of a bearing according to Claim 1, substantially as herein described.

14. A process for the production of a bearing as herein described with reference to any of Examples 1 to 8. 40

15. A bearing whenever produced by a process according to any of Claims 1 to 14.

PAGE, WHITE & FARRER,  
Chartered Patent Agents,  
27 Chancery Lane,  
London, W.C.2.  
Agents for the Applicants.

**THIS PAGE BLANK (USPTO)**